

# EXHIBIT 7

## (PART 4 OF 4)

## SECTION 19

### COMPUTER INTERFACE

#### Computer Interface

The standard interface supplied with the 5216 Standard Firmware is compatible with the user inputs to a DEC DR-11B DMA controller. A summary of the interface signals between the DR-11B and the 5216 is shown in table 19-1. All transfers of instructions and data are performed in the DMA mode. Transfers are set up by first loading the word count and bus address registers of the DR-11B, thus specifying the length of the transfer and the starting location in the computer system memory from/to which data is to be transferred. The type of operation (input or output) is then specified by loading the Device Function bits of the CSR of the DR-11B.

DR11-B, Function #1 defines the direction of data transfer.

<u>F1</u>	<u>OPERATION</u>
0	Transfer from Computer to DG
1	Transfer from DG to Computer

Function bit F3 is used to reset Attention and the Device Status Bits (DSTAT, A, B, C). F3 may also be used to mask interrupts.

#### Interrupts

An interrupt to the DR-11B is generated when:

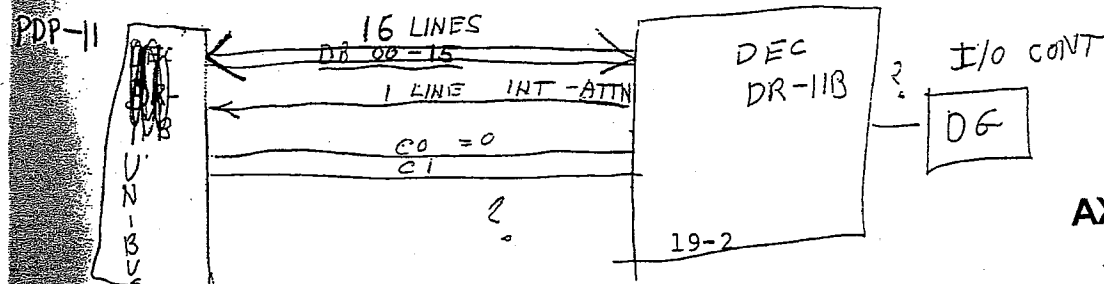
- a. A keystroke is to be transmitted to the computer.
- b. An internal error is detected.
- c. A transfer of data from the Display Generator is completed.

The status bits from the DG to the DR-11B indicate which of the above conditions generated the interrupt. If an operator initiates an operation from a keyboard during an I/O transfer, the DG will wait until the I/O transfer is completed before generating the keyboard interrupt.

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Table 19-1. Interface Signal Summary  
Model 5216 to DEC DR-11B  
DMA Controller

Name	Mnemonic	Function
Output Data Bits 00-15 (16 lines)	DAT00 OUT through DAT15 OUT	Data from UNIBUS to display gen- erator (via DR-11B)
Input Data Bits 00-15 (16 lines)	DAT00 IN through DAT15 IN	Data from display generator to UNIBUS (via DR-11B)
Interrupts (1 line)	ATTN	Interrupt command to the PDP-11 processor
I/O Control (2 lines)	C0, C1	C0 = 0 always C1 = 0: from UNIBUS to Display C1 = 1: from Display to UNIBUS
Output Data Ready or In- put Data Acknowledge (1 line)	END CYCLE	Output Data Ready from DR-11B if C1 = 0. Input Data Acknowledge from DR-11B if C1 = 1
Input Data Ready or Output Data Acknowledge (1 line)	CYCLE REQUEST A	Input Data Ready to DR-11B if C1 = 1. Output Data Acknowledge to DR-11B if C1 = 0
Device Status A, B, C (3 lines)	DSTAT A, B, C	Status lines to DR-11B (FROM 5216)
Device Function 1, 2, 3 (3 lines)	FNCT 1, 2, 3	Control lines from DR-11B to 5216
Ready (1 line)	RDY	Signal to 5216, which when false, indicates that a transfer (DMA) is in progress
Initialize (1 line)	INIT	Not used
Word Count Increment Enable	WC INC ENB	Tied to +5V
Bus Address Increment Enable	BA INC ENB	Tied to +5V
Address 00	A00	Tied to ground
Single Cycle	--	Tied to +5V
Cycle Request B	--	Tied to ground
Busy	BUSY	Signal to 5216, which when true, indicates that a bus cycle (on the UNIBUS) is in progress
Go	GO	Pulse signal to 5216 which causes 5216 to request the first bus cycle of a DMA transfer



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### Device Status Bits (DSTAT A, B, C)

The Device Status Bits produced by the 5216 are defined as follows:

<u>STATUS BIT</u>	<u>FUNCTION</u>
DSTAT A	Keyboard Transmit Request
DSTAT B	End of Transmission (EOT)
DSTAT C	5216 Error
DSTAT A & B	Transmit from ANCS request

### General Device Handler

The software necessary to handle the various transfers to and from the 5216 Display Generator should follow the general structures illustrated in the next section.

### Data Transfer From Computer To Display Generator

The sequence of operations for a transfer to the Display Generator is as follows:

- a. Load 2's complement of word count into DR11-B word count register (DRWC).
- b. Load bus address (core location) of first output data word into DR11-B bus address register (DRBA).
- c. Reset Function #1 (write to DG) in the DR11-B Status and Command register (DRST)
- d. Enable the DR11-B interrupt and start the transfer by setting the GO bit in DRST.

### **Note**

DO NOT reset Function #1 and set GO in the same instruction.  
DO NOT set CYCLE in DRST.

### Data Transfer From Display Generator to Computer

The sequence of operations necessary to read a message from the Display Generator is:

- a. Load 2's complement of word count into DR11-B word count register (DRWC).

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- b. Load bus address of destination (first location where message data is to be put) in DRBA.
- c. Set Function #1 in DRST.
- d. Enable DR11-B interrupt and start transfer by setting GO in DRST.
- e. Upon completion of Read (word count overflow) pulse F3 to reset ATTN and DSTAT B (EOT).

**Note**

DO NOT set Function #1 and set GO in the same instruction.

DO NOT set CYCLE in DRST.

**Termination of I/O via DR11-B**

Termination of a DMA transfer will occur when the DRWC overflows (all 1's to all 0's). This will cause the READY bit of DRST to be set.

If the DR11-B interrupt was enabled as above, an interrupt to the CPU will occur at the end of the DMA transfer.

Any I/O will also be terminated when a 5216 error or EOT condition occurs. A DMA transfer will not be terminated if a keyboard transmit request occurs. This prevents operator intervention during transfer operations.

**Keyboard Arming**

In order to arm (enable) the DR11-B for keystrokes:

- a. Set F1, F2, F3 = 1
- b. Set interrupt enable and GO
- c. Wait for keystroke

Upon receipt of an interrupt for a pending keystroke:

- a. Set F1, F3 = 1; F2 = 0
- b. Set DRWC = -7
- c. Set DRBA
- d. Set F3 = 0
- e. Set GO and interrupt enable

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The seven-word keystroke message will be DMA'ed to the buffer pointed to by DRBA, and DRWC will overflow, producing an interrupt.

Then:

Pulse F3 off, on, and off (0, 1, 0)

The DR11-B and 5216 is now ready for further I/O.

**Note**

Anytime ATTN is set, F3 must be pulsed to reset ATTN and the DSTAT's. The condition of the DSTAT's before this pulse indicates the reason for the ATTN.

DSTAT A - There is a pending keystroke request. A seven-word read as described above must be done after pulsing F3.

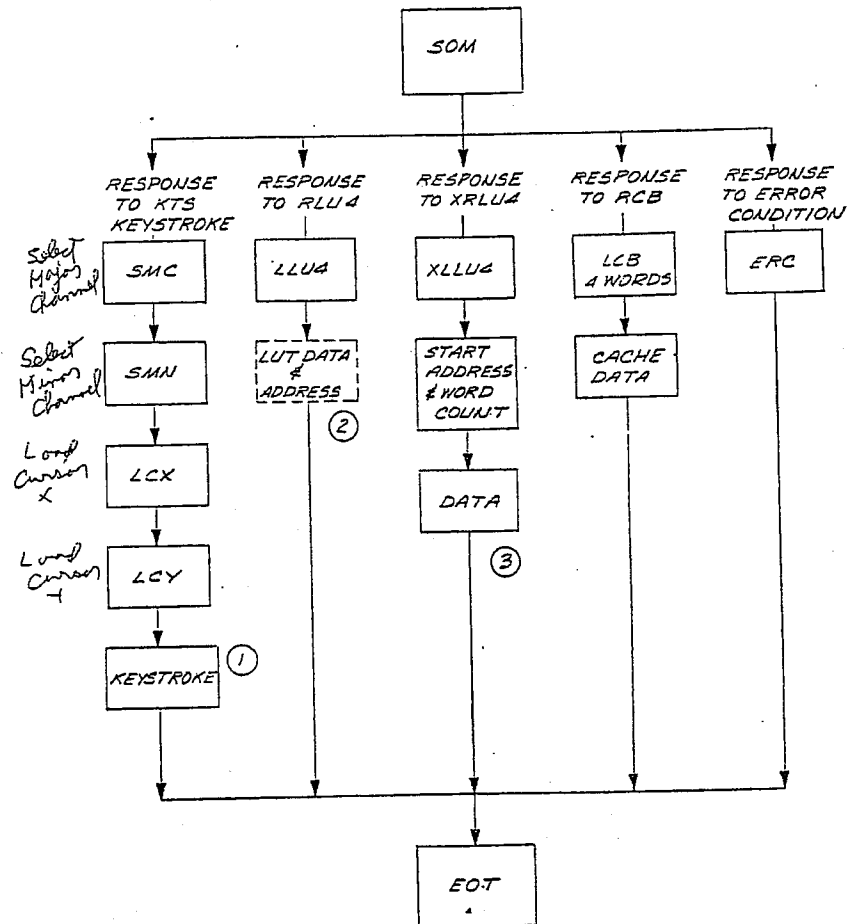
DSTAT B - This indicates an EOT (a readback is complete). Pulse F3 to reset ATTN and DSTAT B.

DSTAT C - This indicates a 5216 error. Pulse F3 and read three words back to get error code.

DSTAT A + B - There is data ready for transmission from the Alphanumeric Channel Set (ANCS).

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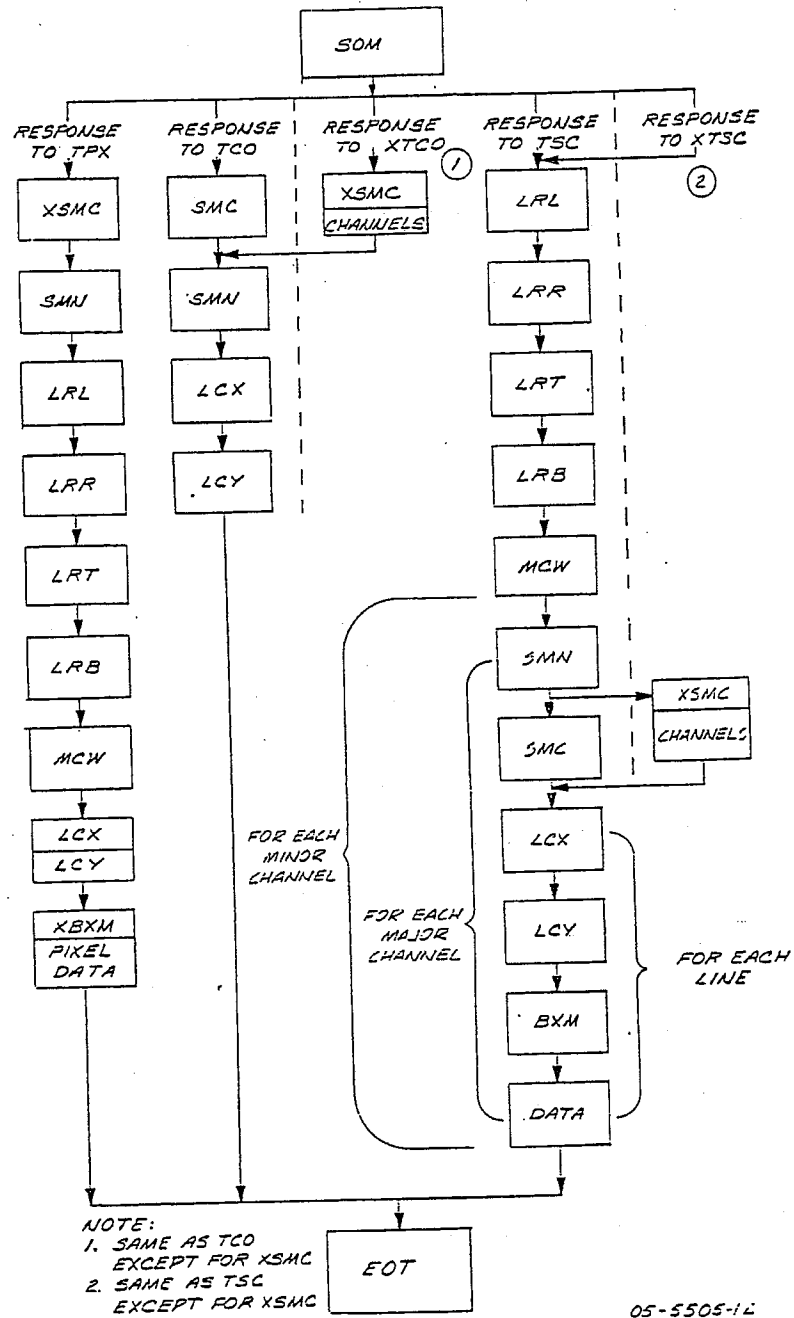
# APPENDIX A TRANSMIT FORMATS



05-5505-2 A

1. ONE KEYSTROKE PER SEQUENCE -(ASCII CODE LOW BITS ; HIGH 8 BITS 0)
2. COLOR WORD TRANSMITTED IF BIT 7 OF WORD #1 OF RLU4 IS SET
3. HIGH 8 BITS 0, LOW EIGHT BITS DATA

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APPENDIX B  
ASCII CHARACTER CODES  
5x7, 10x14 Fonts

Bit	7	X	X	X	X
	6	1	1	0	0
	5	0	1	0	1
	4	3	2	1	0
0000	SPACE	0	@	P	
0001	!	1	A	Q	
0010	"	2	B	R	
0011	#	3	C	S	
0100	\$	4	D	T	
0101	%	5	E	U	
0110	&	6	F	V	
0111	'	7	G	W	
1000	(	8	H	X	
1001	)	9	I	Y	
1010	*	:	J	Z	
1011	+	;	K	[	
1100	,	<	L	\	
1101	-	=	M	]	
1110	.	>	N	^	
1111	/	?	O	_	

7x9 Character Codes

b <sub>7</sub>	b <sub>6</sub>	b <sub>5</sub>	0	0	0	0	1	1	1	1
			0	0	1	1	0	0	1	1
			0	1	0	1	0	1	0	1
b <sub>4</sub>	b <sub>3</sub>	b <sub>2</sub>	b <sub>1</sub>							
0	0	0	0	SPACE	0		@	P	'	P
0	0	0	1	!	1		A	Q	a	q
0	0	1	0	"	2		B	R	b	r
0	0	1	1	#	3		C	S	c	s
0	1	0	0	\$	4		D	T	d	t
0	1	0	1	%	5		E	U	e	u
0	1	1	0	&	6		F	V	f	v
0	1	1	1	'	7		G	W	g	w
1	0	0	0	(	8		H	X	h	x
1	0	0	1	)	9		I	Y	i	y
1	0	1	0	*	:		J	Z	j	z
1	0	1	1	+	;		K	[	k	{
1	1	0	0	,	<		L	\	l	}
1	1	0	1	-	=		M	]	m	~
1	1	1	0	.	>		N	^	n	
1	1	1	1	/	?		O	_	o	SOLID

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## APPENDIX C

## MEMORY ADDRESS

FFFFF

FC000

F8000

10000

08000

07800

00400

00000

PROCESSOR ROM  
8K WORDSOPTIONAL PROCESSOR ROM  
8K WORDSFREE SPACE  
464K WORDS

STANDARD SYSTEM MODULES

EA ROM (SHADOWS RAM)

PROCESSOR RAM  
16K WORDS

INTERRUPT VECTORS

ON PROCESSOR BOARD

OFF BOARD  
ADDRESSING SPACE

ON PROCESSOR BOARD

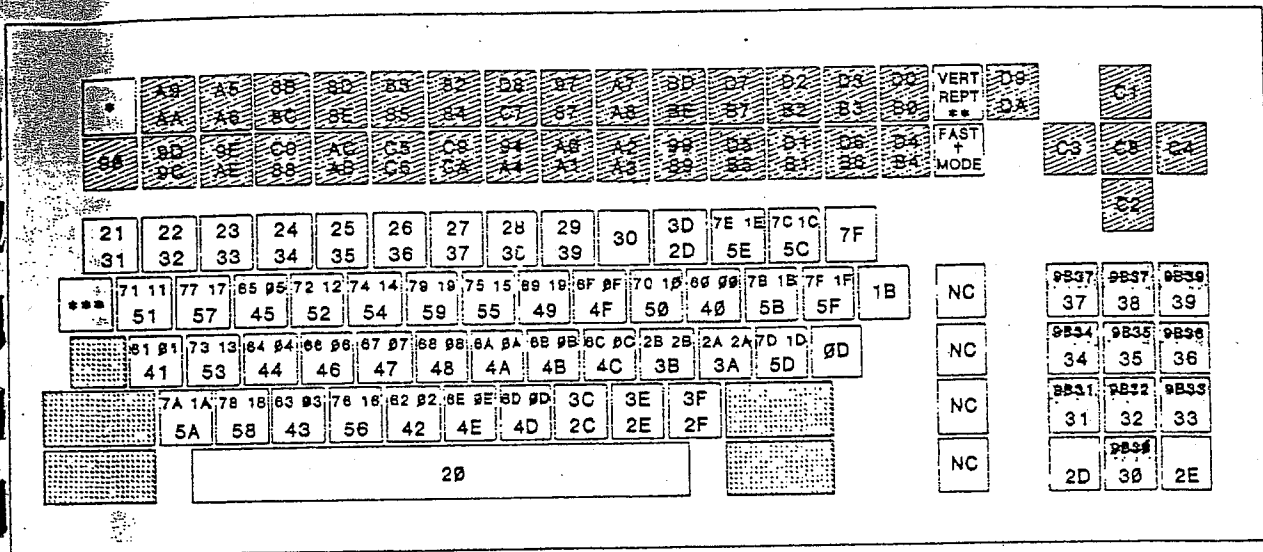
The first hex digit of the memory address is the Device Select digit.

Figure C-1. 5216 System Memory Map

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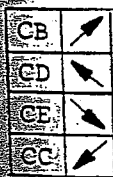
## APPENDIX D

## AYDIN 5116 KEYBOARD - STANDARD FIRMWARE KEYS



04-5491-2

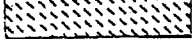
- \* DC Power Indicator - No Switch
- \*\* Produces a double character transmission: Character key code followed by (CCH)
- \*\*\* Causes repeat of previous character
- † Causes 500 characters/second rate
- NC No Code



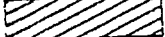
These codes are generated by simultaneous actuation of two orthogonal cursor movement keys designating a quadrant.

Figure D-1. 5116 Keyswitch Codes

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The areas shaded  (shift keys) will produce no serial output but may change the code of the character keyswitch depressed simultaneously.

#### Control Codes

The areas shaded  are control codes and do not place a character on the screen but may cause a visual effect. The actual effect is determined by the 5216. The 5116 simply produces the codes shown in Figure D-1.

It should be noted that the four cursor keys in this field can be combined into pairs. The output code is a unique code to indicate diagonal cursor movement.

#### Function Codes

The areas shaded  are the function code keys and will produce the codes shown in Figure D-1 when a shift and a number code keys are depressed. The function codes will not repeat.

40	41	42	43	44	45	46	47	48	49	50	51	52	53	54
25	26	27	28	29	30	31	32	33	34	35	36	37	38	39
10	11	12	13	14	15	16	17	18	19	20	21	22	23	24

Figure D-2. Decimal Numbering of Buttons on a 45 Function Keypad

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## APPENDIX E

2	3	4	5	6	7	8	9	10	11	12	13	14	15
DC POWER	REV BKGD NOR	ADD MODE REPL	LUT*1 5x7	XKB 10x14	XCB PROG	MEMOR EAKOM	LKB WRIT G	TKB MCVE G	ALPHA KYBD GRAPHIC	LTC ERASE	RBC CENTER	CCL WORD	ZOOM F/PIXL
16	17	18	19	20	21	22	23	24	25	26	27	28	29
CLEAR	BUFF XMIT SCREEN	LINE XMIT CURSOR	LOAD INDEX	LP SCROLL DWN	LOAD COLOR TABLE	MWGR SEL CH MAJOR	LEFT ROLL RIGHT	PALETT SPECIAL	DEST IN-DEST	LTR CLR I	RBR COPY	CRL PIXEL	FILL B/PIXL
30	31	32	33	34	35	36	37	38	39	40	41	42	43
REPEAT	q G	W W	e E	r R	t T	y Y	u U	i I	o O	p P	~ Σ	! ↑	DELETE
SHIFT LOCK	a A	s S	d D	f F	g G	h H	j J	k K	l L	~ Σ	! ↑	DELETE	ESC
CONTROL SHIFT	z Z	x X	c C	v V	b B	n N	m M	< ;	> :	? /	CONTROL SHIFT	SHIFT	803-5194 (sht. 2)
SHIFT													

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Figure E-1. Function Code Keytop Engravings for Standard Firmware

COLOR VALUES	
00	Black
07	Red
38	Green
3F	Yellow
C0	Blue
C7	Magenta
F8	Cyan
FF	White

Figure E-2. Color Value Chart for the VID-004 Card

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## APPENDIX F

5116 FUNCTION CODES FOR  
STANDARD FIRMWARE AND ANCS  
(REFER TO FIGURE E-1)

AX20937 5116 Switch #	Shift No Shift	Function Code (Hexadecimal)	5216 Standard Firmware	ANCS Function
2	Shift No Shift	A9 AA	Background Reverse Background Normal	Reverse Video Normal Video
3	Shift No Shift	A5 A6	Add Mode Replace Mode	Blink On Blink Off
4	Shift No Shift	8B 8C	LUT #1 5 X 7 Font	Relay On Relay Off
5	Shift No Shift	8D 8E	LUT #2 7 X 9 Font	Erase Page Clear Line
6	Shift No Shift	8E 85	Execute Keyboard Buffer 10 X 14 Font	Delete Line Insert Line
7	Shift No Shift	82 84	Execute Cache Buffer Programmable Font	Delete Character Insert Character
8	Shift No Shift	D8 C7	Memory Not Available	Not Available Split
9	Shift No Shift	97 87	Load Keyboard Buffer Write Graphic	Direct Addressing Relative to Memory Rotate
10	Shift No Shift	A7 A8	Terminate Keyboard Buffer Move Graphic	Intensity Half Intensity Full
11	Shift No Shift	BD BE	Attach Keyboard to ANCS Attach Keyboard to Graphics	Attach Keyboard to ANCS Attach Keyboard to Graphics
12	Shift No Shift	D7 B7	Left Top Conic Erase Mode	Not Available White
13	Shift No Shift	D2 B2	Right Bottom Conic Cursor to Center	Not Available Green

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AYDIN 5116 Switch #	Shift/ No Shift	Function Code (Hexadecimal)	5216 Standard Firmware	ANCS Function
14	Shift No Shift	D3 B3	Clear Left Conic Word Mode	Not Available Yellow
15	Shift No Shift	D0 B0	ZOOM Load Foreground Pixel	Not Available Black
16	Shift No Shift	9D 9C	Interrupt Interrupt	Xmit BUFFER Xmit SCREEN
17	Shift No Shift	9E AE	Interrupt Interrupt	Xmit Line Xmit Cursor
18	Shift No Shift	C0 88	Execute Circle Execute Vector	Built-in Test & Pattern Program Enter
19	Shift No Shift	AC AB	Not Available Load Index	Large Character Small Character
20	Shift No Shift	C5 C6	Scroll Up Scroll Down	Scroll Up Scroll Down
21	Shift No Shift	C9 CA	Not Available Load Color Table	Page Up Page Down
22	Shift No Shift	9A A4	Select Minor Channel Select Major Channel	Reset Attributes Format
23	Shift No Shift	A0 A1	Roll Left Roll Right	A/N Attribute Alpha
24	Shift No Shift	A2 A3	Pallet Special Font	Numeric Protect
25	Shift No Shift	99 89	Destructive Non-Destructive	Activate Continuous Scroll Tab
26	Shift No Shift	D5 B5	Left Top Rectangle Clear to l's	Not Available Magenta



ATDUB 5116 Switch #	Shift No	Function Code (Hexadecimal)	5216 Standard Firmware	ANCS Function
27	Shift No Shift	D1 B1	Right Bottom Rectangle Copy	Not Available Red
28	Shift No Shift	D6 B6	Clear Rectangular Limits Pixel Mode	Not Available Cyan
29	Shift No Shift	D4 B4	Fill Load Background Pixel	Not Available Blue

F-3/F-4

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## APPENDIX G

### OPERATION CODE SUMMARY

This appendix should have the commands listed (with diagrams) in the following order: Those w/out page numbers will have to be completed when tex is prepared.

START OF MESSAGE (SOM) pg. 2-1

LOAD RECTANGULAR LIMITS (LRR, LRL, LRT, LRB) pg. 3-1

MODE CONTROL WORD (MCW) pg. 4-1

ADJUSTABLE CURSOR ADVANCE (ACA) pg. 5-2

CURSOR POSITIONING (LCX, LCY, CUR) pg. 5-3

VISIBLE CURSOR CONTROL (VCC) pg. 5-5

LOAD INDEX REGISTERS (LIX, LIY) pg. 5-5

LOAD ALPHANUMERIC CHARACTER (LAC) pg. 6-2

LOAD PROGRAMMABLE FONT (LPF) pg. 6-3

WRITE PIXEL VALUE (WPX, WPXF, WPXB) pg. 7-1, 7-2

LOAD GRAPHIC ELEMENTS (LGE) pg. 7-2

EXECUTE CONIC INSTRUCTION (EXC) pg. 7-3

LOAD CONIC LIMITS (LCLL, LCLR, LCLT, LCLB) pg. 7-4

BLOCK TRANSFER MODE (BXM) pg. 8-1

EXTENDED BLOCK TRANSFER MODE (XBXM) pg. 8-4

EDIT INSTRUCTION (EDT) pg. 9-1

EXTENDED EDIT (XEDT) pg. 9-3

ZOOM pg. 9-3

FILL pg. 9-3

COPY pg. 9-4

LOAD PIXEL REGISTERS (LRXF, LPXB) pg. 10-2

SELECT MAJOR CHANNEL (SMC) pg. 11-2

SELECT MINOR CHANNELS (SMN) pg. 11-2

MASK MAJOR CHANNEL (MMC) pg. 11-3

MASK MINOR CHANNELS (MMN) pg. 11-3

EXTENDED SELECT MAJOR CHANNEL (XSMC) pg. 11-4

EXTENDED MASK MAJOR CHANNEL (XMMC) pg. 11-4

LOAD LOOKUP TABLE 004 (LLU4) pg. 12-3

EXTENDED LOAD LOOKUP TABLE (XLLU4) pg. 12-4

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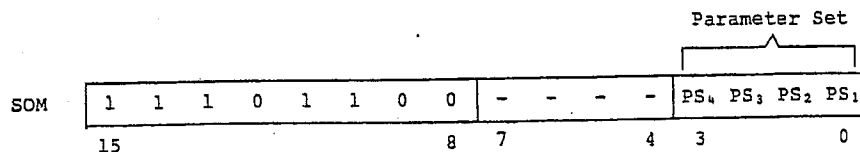
READ LOOKUP TABLE 004 (RLU4) pg. 12-4  
EXTENDED READ LOOKUP TABLE 004 (XRLU4) pg. 12-5  
CURSOR POSITION READBACK (TCO) pg. 13-1  
EXTENDED CURSOR POSITION READBACK (XTCO) pg. 13-2  
MEMORY DATA READBACK (TSC) pg. 13-3  
EXTENDED MEMORY DATA READBACK (XTSC) pg. 13-3  
TRANSMIT PICTURE ELEMENTS (TPX) pg. 13-3  
KEYBOARD TRANSMIT STATUS (KTS) pg. 13-4  
END OF TRANSMISSION (EOT) pg. 13-6  
LOAD CACHE BUFFER (LCB) pg. 14-1  
READ CACHE BUFFER (RCB) pg. 14-2  
EXECUTE CACHE BUFFER (XCB) pg. 14-3  
EXECUTE KEYBOARD BUFFER (XKB) pg. 14-4  
STANDARD LIST INSTRUCTIONS pgs. 17-5 through 17-8

SELECT DEVICE (SDEV) pg. 15-1  
ERROR CODE (ERC) pg. 16-1/16-2

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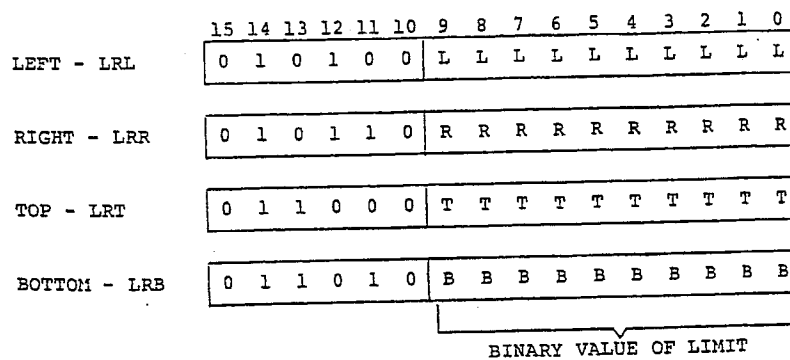
## OPERATION CODE SUMMARY

Start of Message - SOM (page 2-1)

Parameters

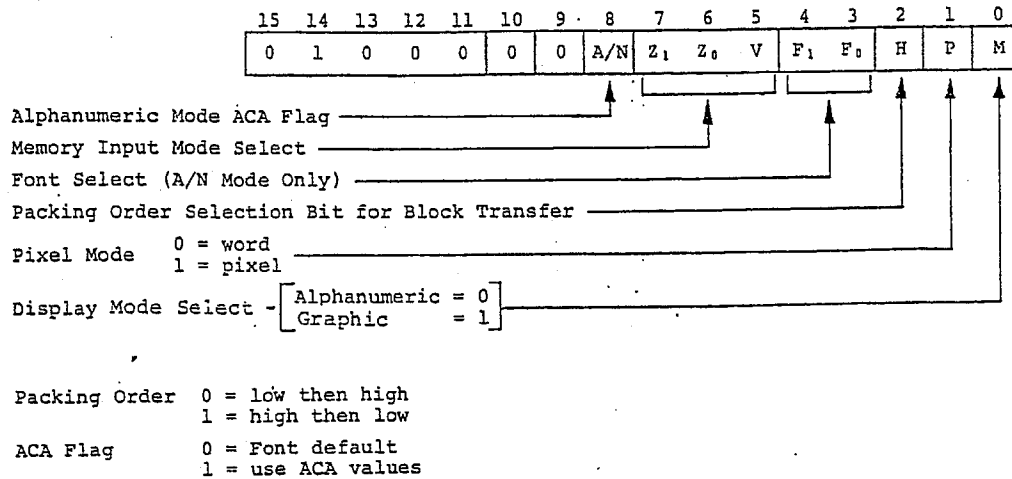
- MAJOR Channel Selects
- MINOR Channel Select
- MAJOR Channel Mask
- MINOR Channel Mask
- Mode Control Word
- X - cursor position
- Y - cursor position
- X - index
- Y - index
- Foreground pixel value
- Background pixel value
- Rectangular limits
- Conic limits
- ACA values
- KTS

Load Rectangular Limits - LRR, LRL, LRT, LRB (page 3-1)



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## Mode Control Word - MCW (page 4-1)



## Standard Font Cursor Advance (page 4-3)

				Cursor Advance in Selected Font (number of picture elements)	
Bit No.	4	3	Font Selected	X	Y
0	0		5 x 7	8	10
0	1		7 x 9	10	14
1	0		10 x 14	16	16
1	1		16 x 15 (Programmable Font)	x-cur.adv.	y-pitch

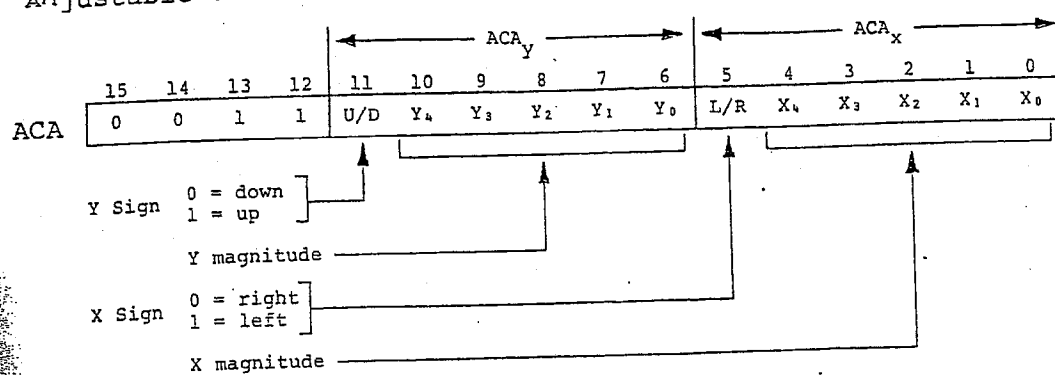
Bits 3 and 4 have no effect in the graphic mode.  
The X and Y cursor advances shown are used unless  
bit 8 of MCW is set.

## Memory Input Mode Selection (page 4-3)

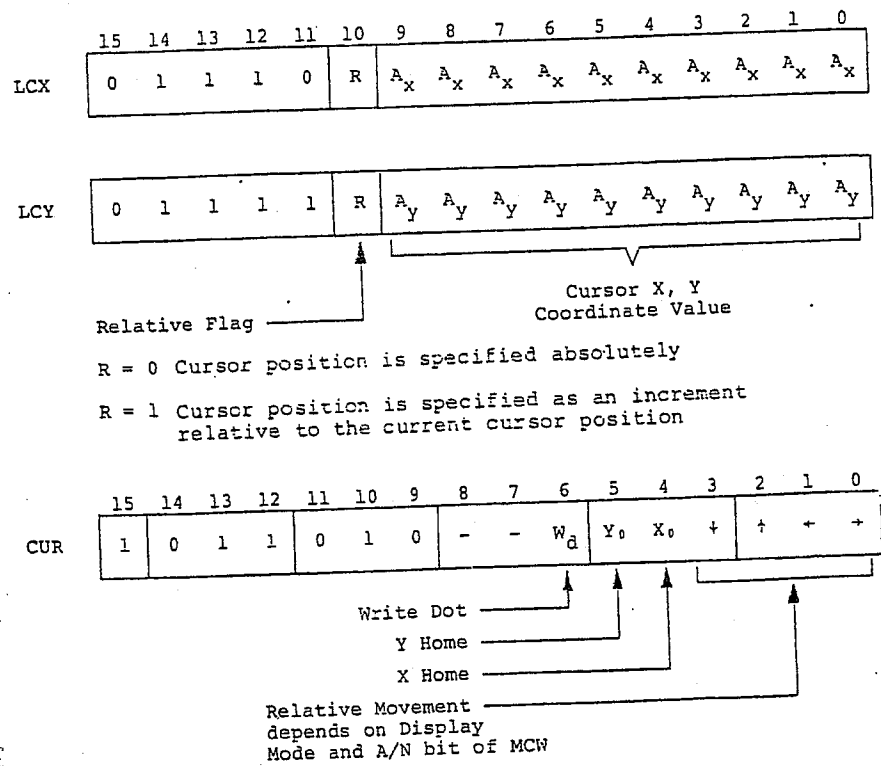
MCW Bit No.	7	6	5	Memory Input Mode
Designation	Z <sub>1</sub>	Z <sub>0</sub>	V	
	0	0	0	OR Ones
	0	1	0	Replace Normal
	0	1	1	Replace Reverse
	1	0	0	Erase Ones
	1	1	X	Not Defined

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## Adjustable Cursor Advance (ACA) pg. 5-2



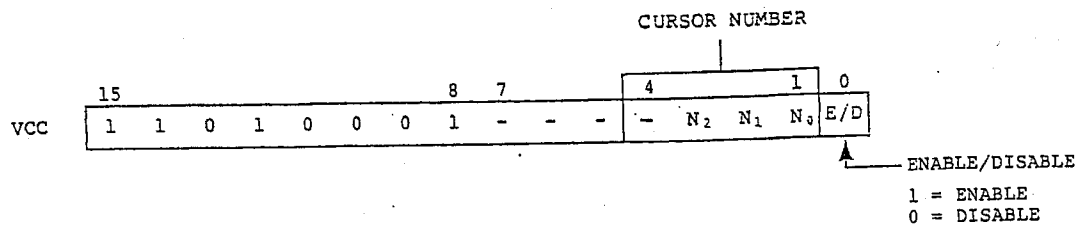
## Cursor Positioning - LCX, LCY, CUR (page 5-3)



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## Visible Cursor Control - VCC (page 5-5)

\*EXT



## Load Index Registers - LIX, LIY (page 5-5)

	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
LIX	1	0	0	0	0	0	A <sub>9</sub>	A <sub>8</sub>	A <sub>7</sub>	A <sub>6</sub>	A <sub>5</sub>	A <sub>4</sub>	A <sub>3</sub>	A <sub>2</sub>	A <sub>1</sub>	A <sub>0</sub>

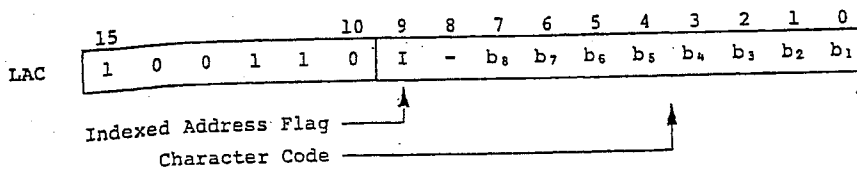
  

	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
LIY	1	0	0	0	0	1	A <sub>9</sub>	A <sub>8</sub>	A <sub>7</sub>	A <sub>6</sub>	A <sub>5</sub>	A <sub>4</sub>	A <sub>3</sub>	A <sub>2</sub>	A <sub>1</sub>	A <sub>0</sub>

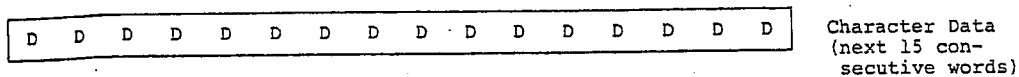
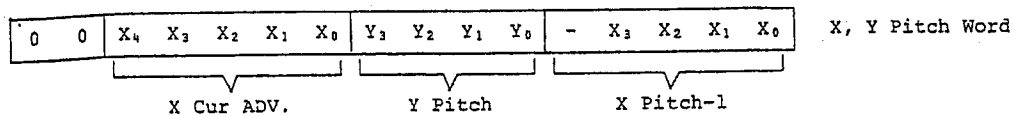
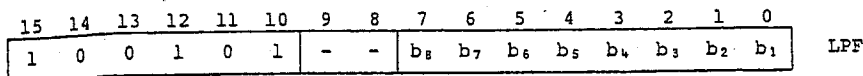
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## Load Alphanumeric Character - LAC (page 6-2)



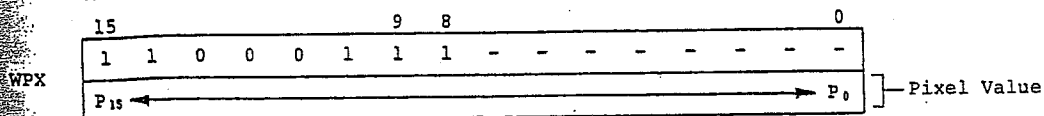
## Load Programmable Font - LPF (page 6-3)



## Write Pixel Values - WPX, WPXF, WPXB (pages 7-1, 7-2)

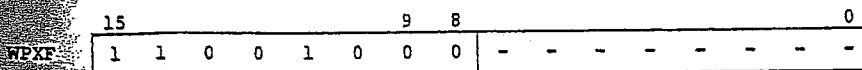
\* EXT

## Write Pixel



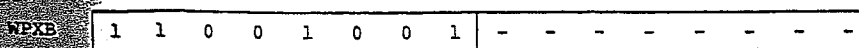
## Write Pixel - Foreground

\* EXT



## Write Pixel - Background

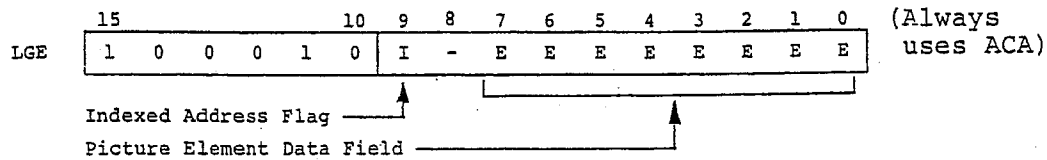
\* EXT



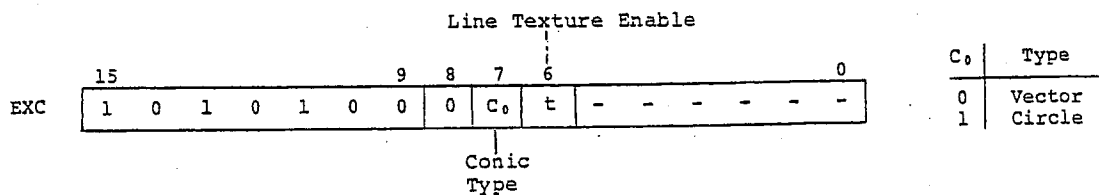
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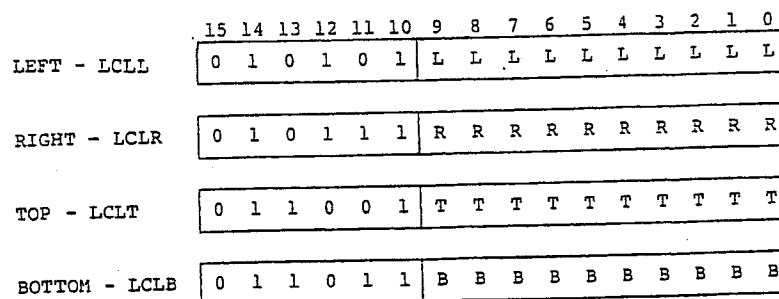
## Load Graphic Elements - LGE (page 7-2)



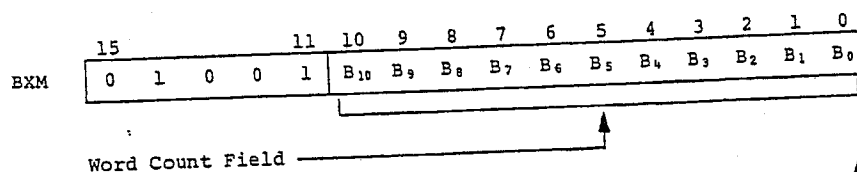
## Execute Conic - EXC (page 7-3)



## Load Conic Limits - LCLL, LCLR, LCLT, LCLB (page 7-4)



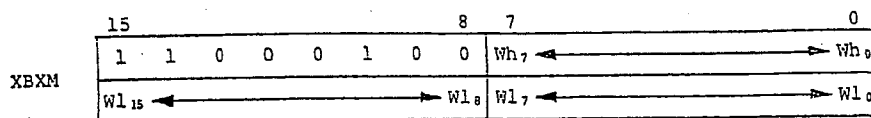
## Block Transfer Mode - BXM (page 8-1)



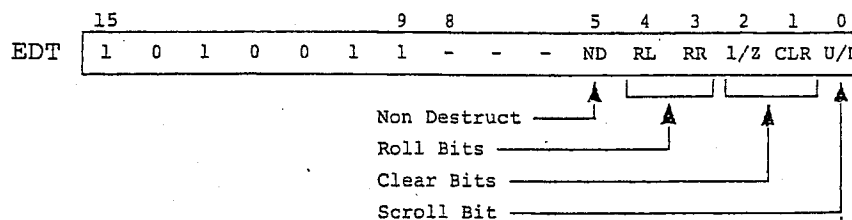
AX209947

## Extended Block Transfer - XBXM (page 8-4)

\* EXT



## Scrolling, Rolling, Clearing - Edit Instruction EDT (page 9-1)



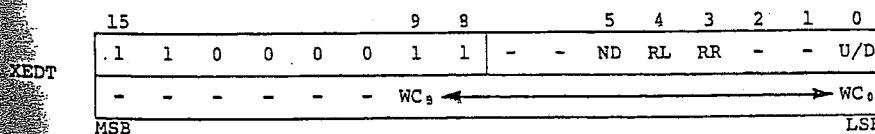
ND = 1 is non-destructive  
 ND = 0 is destructive

U/D = 1 Up  
 = 0 Down

Bit No.	2	1	0		Meaning	Bit	4	3	Meaning
	1/Z	CLR	SCR						
	0	0	0		Scroll Down		0	1	Roll Right
	0	0	1		Scroll Up		1	0	Roll Left
	0	1	0		Clear to Zeros		1	1	Danger
	1	1	0		Clear to Ones				

## Extended Edit - XEDT (page 9-3)

\*EXT



U/D = 1 Up  
 = 0 Down

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Zoom, Fill, Copy (pages 9-3, 9-4)

	15						8	7						0
ZOOM	1	1	1	0	0	1	1	0	-	-	-	-	-	-

\* EXT

	15		8	7				0
FILL	1	1	1	0	0	1	1	1
	-	-	-	-	-	-	-	-

\* EXT

															TYPE CODE		
															2	1	0
15							8	7									
COPY	1	1	0	1	0	1	0	0	-	-	-	-	-	-	-	T <sub>1</sub>	T <sub>0</sub>
	D <sub>15</sub>															D <sub>0</sub>	
	D <sub>15</sub>															D <sub>0</sub>	

\* EXT

Pixel Value #1

Pixel Value #2  
(optional)

T <sub>1</sub>	T <sub>0</sub>	Number of Parameter Words	Will Copy
0	0	1	non-zero after AND
0	1	1	equals
1	0	2	in range
1	1	2	not in range

**AX209949**

## Load Pixel Registers (page 10)

Load Pixel Value - Foreground

\*EXT

	15	9	8	0												
LPXF	1	1	0	0	0	1	0	1	-	-	-	-	-	-	-	-
PIXEL VALUE	P <sub>15</sub> ————— P <sub>0</sub>															

Load Pixel Value - Background

\*EXT

	15					9	8								0
LFXB	1	1	0	0	0	1	1	0	-	-	-	-	-	-	-
PIXEL VALUE	P <sub>15</sub> ————— P <sub>0</sub>														

Select Major Channel - SMC (page 11-2)

	15					12	11								0	Bit No.
SMC	0	0	0	1	c	c	c	c	c	c	c	c	c	c	c	c
					12	11	10	9	8	7	6	5	4	3	2	1
	Channel number selected by corresponding bit number															

Select Minor Channel - SMN (page 11-2)

	15						9	8				4	3	2	1	0
SMN	1	0	1	0	0	0	0	-	-	-	-	S <sub>4</sub>	S <sub>3</sub>	S <sub>2</sub>	S <sub>1</sub>	
	Minor Channel Select Field															
	Refers to hardware optional configuration															

Mask Major Channel - MMC (page 11-3)

	15						12	11								0
MMC	0	0	1	0	c	c	c	c	c	c	c	c	c	c	c	c
					12	11	10	9	8	7	6	5	4	3	2	1
	Channel number masked by corresponding bit number															
	Error generated by masking selected or selecting masked channel															

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## Mask Minor Channel - MMN (page 11-3)

MMN

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	1	0	0	0	1	-	-	-	-	-	S <sub>4</sub>	S <sub>3</sub>	S <sub>2</sub>	S <sub>1</sub>

Minor Channel  
masked by  
corresponding  
bit, as in SMN

Extended Select Major Channel - XSMC (page 11-4)

\*EXT

	15						9	8							0	
XSMC	1	1	0	0	0	0	0	-	-	-	-	-	-	-	-	
	c	c	c	c	c	c	c	c	c	c	c	c	c	c	c	
	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1

Bit Map

Extended Mask Major Channel - XMMC (page 11-4)

\*EXT

	15						9	8							0
XMMC	1	1	0	0	0	0	0	1	-	-	-	-	-	-	-
	c	c	c	c	c	c	c	c	c	c	c	c	c	c	c
	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2

Bit Map

Load Lookup Table 004 - LLU4 (page 12-3)

\*EXT

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LLU4

Diagram illustrating the structure of the 16-bit word (LLU4):

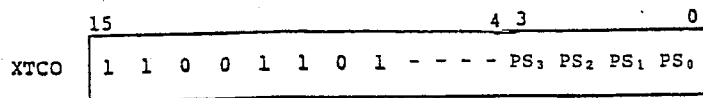
Color Word Enable										Status Enable					
15						9	8	7	6	5		2	1	0	
1	0	1	0	1	1	0	-	CE	SE	STATUS WORD S <sub>4</sub> S <sub>3</sub> S <sub>2</sub> S <sub>1</sub>			TBL # T <sub>1</sub> T <sub>0</sub>		
A <sub>8</sub>	A <sub>7</sub>	A <sub>6</sub>	A <sub>5</sub>	A <sub>4</sub>	A <sub>3</sub>	A <sub>2</sub>	A <sub>1</sub>	B <sub>2</sub>	B <sub>1</sub>	G <sub>3</sub>	G <sub>2</sub>	G <sub>1</sub>	R <sub>3</sub>	R <sub>2</sub>	R <sub>1</sub>
TABLE ADDRESS															

Optional depending  
on CW  
CE = 1 expects  
second word

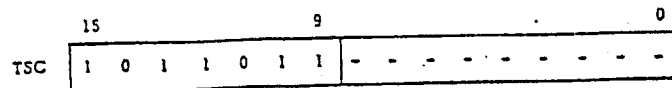


## Extended Cursor Position Readback - XTCO (page 13-2)

\*EXT



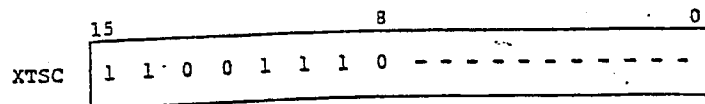
Memory Data Readback - TSC (page 13-3)



## Extended Memory Data Readback - XTSC (page 13-3)

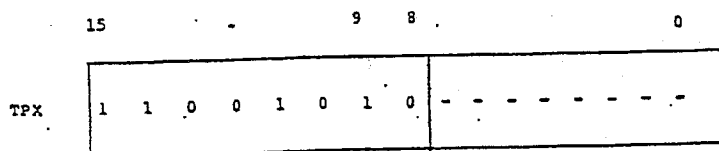
\*EXT

- Uses BXN Word mode
- one channel at a time.



Transmit Picture Elements - TPX (page 13-3)

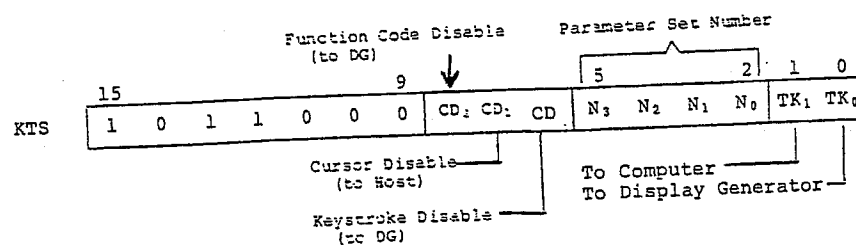
\*EXT



Uses BXM Pixel Mode

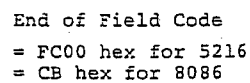
Keyboard Transmit Status - KTS (page 13-4)

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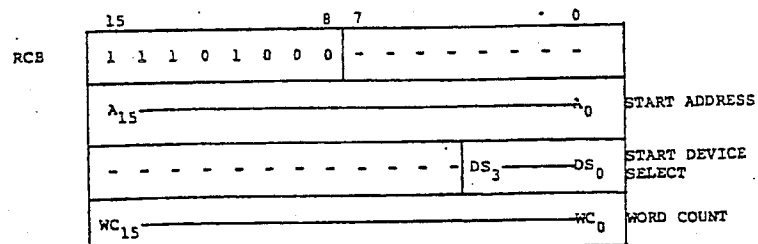
Load Cache Buffer -- LCB (page 14-1)

\*EXT



Read Cache Buffer - RCB (page 14-2)

\*EXT

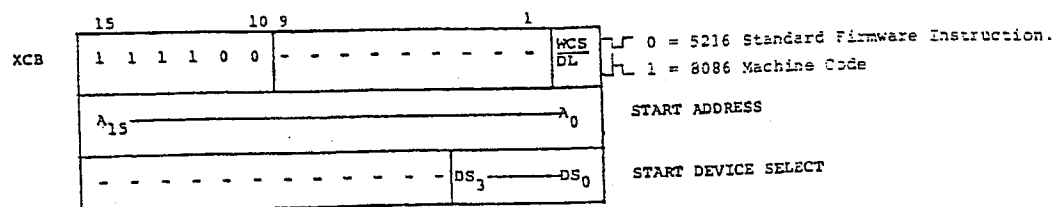


G-13



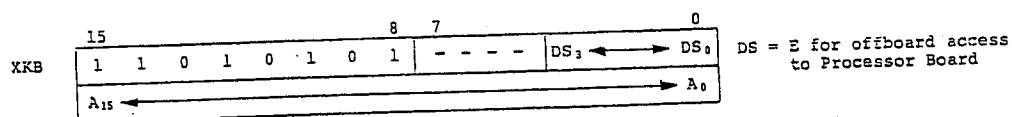
Execute Cache Buffer - XCB (page 14-3)

\*EXT



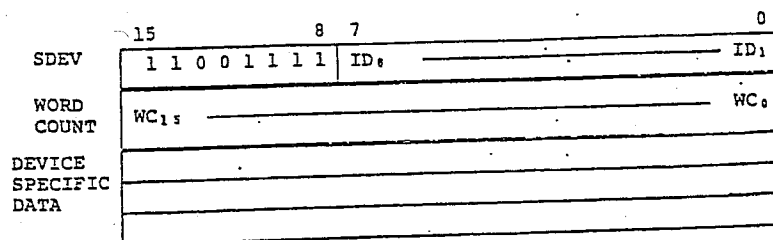
Execute Keyboard Buffer - XKB (page 14-4)

\*EXT



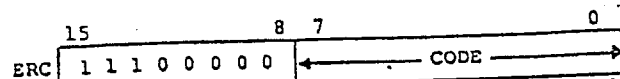
Select Device - SDEV (page 15-1)

\*EXT



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Error Code - ERC (page 16-1)



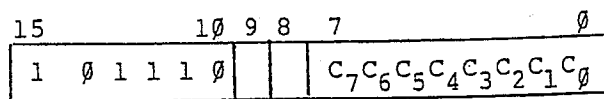
Code

- 1 Host/5216 Communications Error
- 3 Cursor out of limits
- 8 Illegal (syntax) instruction

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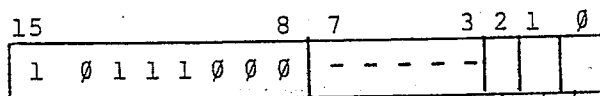
## Standard List Instructions (pages 14-5 through 14-8)

SETCTR



COUNTER NUMBER = 1, 2, or 3

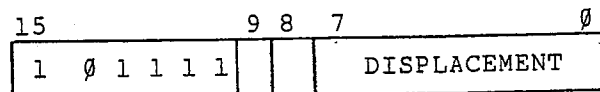
INCCTR



0 = INCREMENT  
1 = DECREMENT

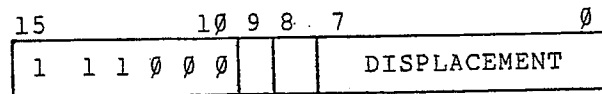
COUNTER NUMBER =  
1, 2, or 3

LOOP



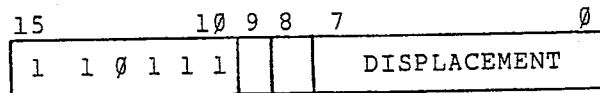
COUNTER NUMBER = 1, 2, or 3

JMPZ



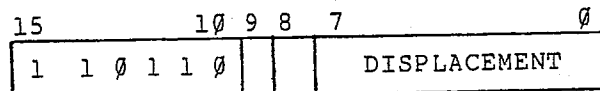
COUNTER NUMBER = 1, 2, or 3

JMPPOS



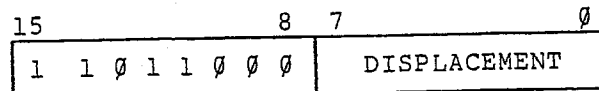
COUNTER NUMBER = 1, 2, or 3

JMPNEG



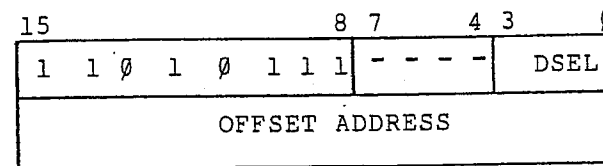
COUNTER NUMBER = 1, 2, or 3

JMPL



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ALIST



G-17.

## Instruction Set Summary

	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
NOP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-
SMC	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	C <sub>1</sub>
MMC	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	C <sub>2</sub>
ACA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	C <sub>3</sub>
ADJUSTABLE CURSOR ADVANCE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	C <sub>4</sub>
MODE CONTROL WORD	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	C <sub>5</sub>
BLOCK TRANSFER MODE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	C <sub>6</sub>
LOAD RECTANGULAR LIMIT LEFT	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	C <sub>7</sub>
LOAD RECTANGULAR LIMIT RIGHT	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	C <sub>8</sub>
LOAD RECTANGULAR LIMIT TOP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	C <sub>9</sub>
LOAD RECTANGULAR LIMIT BOTTOM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	C <sub>10</sub>
LOAD CURSOR X	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	C <sub>11</sub>
LOAD CURSOR Y	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	C <sub>12</sub>
LOAD INDEX X REG.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	C <sub>13</sub>
LOAD INDEX Y REG.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	C <sub>14</sub>
LOAD GRAPHIC ELEMENTS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	C <sub>15</sub>
TRANSMIT CURSOR ONLY	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	C <sub>16</sub>
LOAD PROGRAMMABLE FONT	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	C <sub>17</sub>
LOAD ALPHANUMERIC CHAR.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	C <sub>18</sub>
SELECT MINOR CHANNEL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	C <sub>19</sub>
MASK MINOR CHANNEL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	C <sub>20</sub>
EDIT	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	C <sub>21</sub>
EXECUTE CONIC	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	C <sub>22</sub>
KEYBOARD TRANSMIT STATUS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	C <sub>23</sub>
CURSOR MOVEMENT	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	C <sub>24</sub>
TRANSMIT SELECTED CHANNEL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	C <sub>25</sub>
END TRANSMISSION CODE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	C <sub>26</sub>
START OF MESSAGE CODE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	C <sub>27</sub>
SOM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	C <sub>28</sub>

- Indicates "don't care" bit

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# APPENDIX H

## EXTENDED INSTRUCTION SET SUMMARY

### Extended Instruction Set (cont)

Variable Cursor Control	VCC	1	1	0	1	0	0	0	1	1	-	-	-	N <sub>3</sub>	N <sub>2</sub>	N <sub>1</sub>	N <sub>0</sub>	E/D
Write Pixel Value	WPX	1	1	0	0	0	1	1	1	1	-	-	-	-	-	-	-	-
Pixel Value	Data	P <sub>15</sub>	→															P <sub>0</sub>
Write Pixel Foreground	WPXF	1	1	0	0	1	0	0	0	0	-	-	-	-	-	-	-	-
Write Pixel Background	WPXB	1	1	0	0	1	0	0	1	1	-	-	-	-	-	-	-	-
Extended Block Transfer	XBXM	1	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Low Bytes XBXM	Data	WL <sub>15</sub>	→															WL <sub>0</sub>
Extended Edit	XEDT	1	1	0	0	0	0	1	1	1	-	-	-	ND	RL	RR	-	U/D
ZOOM	ZOOM	1	1	1	0	0	1	1	0	-	-	-	-	-	-	-	-	-
FILL	FILL	1	1	1	0	0	1	1	1	1	-	-	-	-	-	-	-	-
COPY	COPY	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	0
Pixel Value #1	Data	D <sub>15</sub>	→															T <sub>0</sub>
Pixel Value #2 (optional)	Data	D <sub>15</sub>	→															D <sub>0</sub>
Load Pixel Register Foreground	LPXF	1	1	0	0	0	1	0	1	0	1	-	-	-	-	-	-	-
Pixel Value	Data	P <sub>15</sub>	→															P <sub>0</sub>
Load Pixel Register Background	LPXB	1	1	0	0	0	1	1	0	1	0	-	-	-	-	-	-	-
Pixel Value	Data	P <sub>15</sub>	→															P <sub>0</sub>

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## Extended Instruction Set

	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Extended Select Major Channel	1	1	0	0	0	0	0	-	-	-	-	-	-	-	-	-
Channel Bit Map	C <sub>15</sub> →															
Extended Mask Major Channel	1	1	0	0	0	0	0	1	-	-	-	-	-	-	-	-
Channel Bit Map	C <sub>0</sub> →															
Load Look Up Table - 4	1	0	1	0	1	1	0	-	CW	SE	S <sub>4</sub>	S <sub>3</sub>	S <sub>2</sub>	S <sub>1</sub>	T <sub>1</sub>	T <sub>0</sub>
Address and Color Value	A <sub>0</sub> → A <sub>1</sub> B <sub>2</sub> B <sub>1</sub> G <sub>3</sub> G <sub>2</sub> G <sub>1</sub> R <sub>3</sub> R <sub>2</sub>															
Read Look Up Table - 4	1	0	1	0	1	1	1	-	CW	SE	-	-	-	-	T	T <sub>1</sub>
Table Address	A <sub>0</sub> → A <sub>1</sub>															
Extended Load Look Up Table - 4	1	1	0	0	1	0	1	1	1	S <sub>4</sub>	S <sub>3</sub>	S <sub>2</sub>	S <sub>1</sub>	T <sub>3</sub>	T <sub>2</sub>	T <sub>1</sub>
Address and Word Count	A <sub>0</sub> → A <sub>1</sub> N <sub>7</sub> →															
N Words Color Value	- - - - - C <sub>7</sub> →															
Extended Read Look Up Table - 4	1	1	0	0	1	1	0	0	1	S <sub>4</sub>	S <sub>3</sub>	S <sub>2</sub>	S <sub>1</sub>	T <sub>3</sub>	T <sub>2</sub>	T <sub>1</sub>
Address and Word Count	A <sub>7</sub> → A <sub>0</sub> N <sub>7</sub> →															
Extended Cursor Position Readback	1	1	0	0	1	1	0	1	-	-	-	-	PS <sub>3</sub>	PS <sub>2</sub>	PS <sub>1</sub>	PS <sub>0</sub>
Extended Memory Data Readback	1	1	0	0	1	1	1	0	-	-	-	-	-	-	-	-
Transmit Picture Elements	1	1	0	0	1	0	1	0	-	-	-	-	-	-	-	-

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## Extended Instruction Set (cont)

	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0							
Load Cache Buffer	1	1	1	0	0	1	0	-	-	-	-	-	-	-	-	-	LCB						
Address	A <sub>15</sub> → A <sub>0</sub>																Data						
Device Select	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	Data						
Word Count	WC <sub>15</sub> → WC <sub>0</sub>																Data						
N-1 words Data	D <sub>15</sub> → D <sub>0</sub>																Data						
End of Field	FC00 hex or CB hex																Data						
Read Cache Buffer	1	1	1	0	1	0	0	0	-	-	-	-	-	-	-	-	RCB						
Start Address	A <sub>15</sub> → A <sub>0</sub>																Data						
Device Select	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	Data						
Word Count	WC <sub>15</sub> → WC <sub>0</sub>																Data						
Execute Cache Buffer	1	1	1	1	0	0	-	-	-	-	-	-	-	-	-	-	XCB						
Start Address	A <sub>15</sub> → A <sub>0</sub>																Data						
Device Select	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	Data						
Execute Keyboard Buffer	1	1	0	1	0	1	0	1	-	-	-	-	-	-	-	-	XKB						
Start Address	A <sub>15</sub> → A <sub>0</sub>																Data						
Select Device	1	1	0	0	1	1	1	1	1	ID <sub>F</sub> →							SDEV						
Word Count	WC <sub>15</sub> → WC <sub>0</sub>																Data						
Device Specific Data-N Words	D <sub>15</sub> → D <sub>0</sub>																Data						

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APPENDIX I  
INSTRUCTION SET IN NUMERICAL ORDER

<u>HEX</u>	<u>OCTAL</u>	<u>MNEMONIC</u>	<u>NAME</u>
0XXX	00XXXX	NOP	NO-OP
1XXX	01XXXX	SMC	Select Major Channel
2XXX	02XXXX	MMC	Mask Major Channel
3XXX	03XXXX	ACA	Adjustable Cursor Advance
40XX	040XXX	MCW	Mode Control Word
48XX	044XXX	BXM	Block Transfer Mode
↓	↓		
4FXX	047XXX		
50XX	050XXX	LRL	Load Rectangular Limit Left
↓	↓		
53XX	051XXX		
54XX	052XXX	LCLL	Load Conic Limit Left
↓	↓		
57XX	053XXX		
58XX	054XXX	LRR	Load Rectangular Limit Right
↓	↓		
5BXX	055XXX		
5CXX	056XXX	LCLR	Load Conic Limit Right
↓	↓		
5FXX	057XXX		
60XX	060XXX	LRT	Load Rectangular Limit Top
↓	↓		
63XX	061XXX		
64XX	062XXX	LCLT	Load Conic Limit Top
↓	↓		
67XX	063XXX		
68XX	064XXX	LRB	Load Rectangular Limit Bottom
↓	↓		
6BXX	065XXX		

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<u>HEX</u>	<u>OCTAL</u>	<u>MNEMONIC</u>	<u>NAME</u>
6CXX ↓	066XXX ↓	LCLB	Load Conic Limit Bottom
6FXX	067XXX		
70XX ↓	070XXX ↓	LCX	Load Cursor X (absolute)
73XX ↓	071XXX ↓		
74XX	072XXX	LCX	Load Cursor X (relative)
77XX	073XXX		
78XX ↓	074XXX ↓	LCY	Load Cursor Y (absolute)
7BXX	075XXX		
7CXX ↓	076XXX ↓	LCY	Load Cursor Y (relative)
7FXX	077XXX		
80XX ↓	100XXX ↓	LIX	Load Index X Register
83XX	101XXX		
84XX ↓	102XXX ↓	LIY	Load Index Y Register
87XX	103XXX		
88XX ↓	104XXX ↓	LGE	Load Graphic Elements
8BXX	105XXX		
8CXX	106XXX	TCO	Cursor Position Readback
94XX	112 XXX	LPF	Load Programmable Font
98XX ↓	114XXX ↓	LAC	Load Alphanumeric Character
9AXX	115XXX		
A0XX ↓	120XXX ↓	SMN	Select Minor Channel
A1XX			
A2XX ↓	121XXX ↓	MMN	Mask Minor Channels
A3XX ↓			
A4XX ↓	122XXX ↓		

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<u>HEX</u>	<u>OCTAL</u>	<u>MNEMONIC</u>	<u>NAME</u>
A5XX	↓		
A6XX	123XXX	EDT	Edit (Clear/Scroll)
A7XX	↓		
A8XX	124XXX	EXC	Execute Conic
A9XX	↓		
AAXX	125XXX		
↓	↓		
ABXX	↓		
ACXX	126XXX	LLU4	Load Lookup Table 4
AEXX	127XXX	RLU4	Read Lookup Table 4
B0XX	130XXX	KTS	Keyboard Transmit Status
B4XX	132XXX	CUR	Cursor Movement
↓	↓		
B5XX			
B6XX	133XXX	TSC	Memory Data Readback
C0XX	140XXX	XSMC	Extended Select Major Channel
C1XX	1404XX	XMMC	Extended Mask Major Channel
C3XX	1414XX	XEDT	Extended Edit
C4XX	142XXX	XBXM	Extended Block Transfer Mode
C6XX	1424XX	LPXF	Load Foreground Pixel Value
C6XX	1430XX	LPXB	Load Background Pixel Value
C7XX	1434XX	WPX	Write Pixel Value
C8XX	1440XX	WPXF	Write Foreground Pixel Value
C9XX	1444XX	WPXB	Write Background Pixel Value
CAXX	1450XX	TPX	Transmit Picture Elements
CBXX	1454XX	XLLU4	Extended Load Lookup Table 4
CCXX	146XXX	XRLU4	Extended Read Lookup Table 4
CDXX	1464XXX	XTCO	Extended Cursor Position Read-back
CEXX	1470XX	XTSC	Extended Memory Data Readback
CFXX	1474XX	SDEV	Select Device
D1XX	1504XX	VCC	Visible Cursor Control
D4XX	1520XX	COPY	Copy
D5XX	1524XX	XKB	Execute Keyboard Buffer
E4XX	162XXX	LCB	Load Cache Buffer
E6XX	1630XX	ZOOM	Zoom
E7XX	1634XX	FILL	Fill

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<u>HEX</u>	<u>OCTAL</u>	<u>MNEMONIC</u>	<u>NAME</u>
E8XX	1640XX	RCB	Read Cache Buffer
ECXX	166XXX	SOM	Start of Message
FXXX	170XXX	XCB	Execute Cache Buffer
FCXX	176XXX	EOT	End of Transmission

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